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The scope of work required 4 tasks to be performed.
This report is divided into 3 different research tasks as required by the scope of work. The three different tasks are briefly described in the introduction. A detailed description is given in sections 2 - 4.
The first task was an establishment of windspeed profiles for specified probabilities of exceedance. Four representative stations in the former area of Yugoslavia were selected and the profiles of the windspeed exceeding certain specified probabilities were given in tables 1 - 4. For comparison the profiles for Berlin, Germany, (Table 5) were included. We learn that the windspeed profiles of the 5 stations are similar except for the mean wind direction profiles.

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The second task required a study of whether the wind speed profile for 13 - 25 km could be predicted given the windspeed from surface to 12 km. Instead of a 26 by 26 matrix system, a 4 coefficient model was developed based on former work utilizing Fourier components which were also used for the probability profiles of section 2. This pilot study for Berlin and Thule resulted in an accounted variance of 70 - 74 %. Although this may be considered low in the first instance, however, the left error for the windspeed is lower than the measuring error, assumed to be 5 m/sec.

The last investigation was a developmemt of a multiple regressionm system for the prediction of veering or backing of the wind in the boundary layer. The study was performed for Berlin and Thule. Unfortunately the result using a matrix to calculate the coefficients contained very low correlations and was not successful at first. Thus an indirect approach was used, calculating the wind direction for 300 and 600 meters with an evaluation of the observed wind direction and the analytical direction by stating whether this was veering or backing. This system resulted in 60 to 80 % correct answwers. Again, Berlin was better than Thule. Due to a delay in receiving data from ETAC, Asheville, NC., and a turned down request for a no cost extension of the contract by procurement no further trials to improve the result could be made.

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REPORT FARMY128.99

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F/DOD/ARMY/AMCOM

Regional Atmospheric Conditions

15 July 1999

Principal Investigator

Dr.Oskar Essenwanger

Prof. Atmosph. and Emvironm. Science

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STATEMENT OF WORK
Study of Regional Atmospheric Conditions
11 November, 1998

1) The contractor shall furnish wind speed profiles from upper air data that is representative of the former Yugoslavia region. The wind speed profile shall be for probability of exceedance, such as 50, 68,84,90,95 and 99. These profiles shall be based on two or more stations from which suitable data is available and should be furnished in a format similar to the report FARMY 108-98. The wind direction profile shall be determined for the entire year as well as seasonally. At least 15 years of data shall be used.

2) The contractor shall study and establish a regression model for wind speeds given the wind profile of the upper air data below 12 km, and predict the wind speed profile above 12 km up to 25 km. This model should be developed for Berlin, and Thule or Montgomery upper air data or Government approved substitute data. The model should be verified by statistical methods. The inclusion of wind direction into this model shall be investigated.

3) The contractor shall develop a prediction model for predicting veering or backing of the wind in the boundary layer (Eckman turn). This model should be developed for wind shear between the surface and 100, 300, and 1000 M based on upper air data from Berlin and Thule or Montgomery or Government approved substitute station.

4) Results from this analysis shall be presented and discussed with personnel of the Battlefield Directorate, White Sands, NM.

ABSTRACT.

The scope of work required 4 tasks to be performed.

This report is divided into 3 different research tasks as required by the scope of work. The three different tasks are briefly described in the introduction. A detailed description is given in sections 2 - 4.

The first task was an establishment of windspeed profiles for specified probabilities of exceedance. Four representative stations in the former area of Yugoslavia were selected and the profiles of the windspeed exceeding certain specified probabilities were given in tables 1 - 4. For comparison the profiles for Berlin, Germany, (Table 5) were included. We learn that the windspeed profiles of the 5 stations are similar except for the mean wind direction profiles.

The second task required a study of whether the wind speed profile for 13 - 25 km could be predicted given the windspeed from surface to 12 km. Instead of a 26 by 26 matrix system, a 4 coefficient model was developed based on former work utilizing Fourier components which were also used for the probability profiles of section 2. This pilot study for Berlin and Thule resulted in an accounted variance of 70 - 74 %. Although this may be considered low in the first instance, however, the left error for the windspeed is lower than the measuring error, assumed to be 5 m/sec.

The last investigation was a developmemt of a multiple regressionm system for the prediction of veering or backing of the wind in the boundary layer. The study was performed for Berlin and Thule. Unfortunately the result using a matrix to calculate the coefficients contained very low correlations and was not successful at first. Thus an indirect approach was used, calculating the wind direction for 300 and 600 meters with an evaluation of the observed wind direction and the analytical direction by stating whether this was veering or backing. This system resulted in 60 to 80 % correct answwers. Again, Berlin was better than Thule. Due to a delay in receiving data from ETAC, Asheville, NC., and a turned down request for a no cost extension of the contract by procurement no further trials to improve the result could be made.

The results could not be presented to the Atmospheric Environmental Battlefield Directorate at White Sands Missile Range due to a postponement (to September) of a visit to White Sands by personnel of the Directorate. The no cost extension of the contract was denied by procurement personnel. The funds for travel were returned by UAH (contract balance).

1. INTRODUCTION.

The requirement for the scope of work has 4 tasks.

The first task is an establishment of probability wind speed profiles from surface to 25 km, exceeding certain probability levels. The profiles are given in tables 1 - 4, and will be discussed in section 2 for four stations in the Balkan region.

The second task is a study to establish a regression model to predict the wind speed from 13 to 25 km given the wind speed from surface to 12 km. This task is discussed in sections 3 for Berlin and Thule.

The third task was the development of a regression model to predict veering or backing of the wind in the boundary layer. This task is discussed in detail in section 4 for Berlin and Thule. The task is very difficult because the linear correlation coefficients for the wind direction differences in the boundary layer are very weak. However, some succuss was achieved by predicting the wind direction directly, and evaluating whether veering or backing occurred.

The 4th task involved travel, as discussed in the abstract.

2. WINDPROFILES FROM SURFACE TO 25 KM AND PROBABILITY TO EXCEED WINDSPEED.

The windspeed profiles have been calculated as outlined in report FARMY108.98 and FARMY125.98 for 4 representative stations in the area of former Yugoslavia and Balkan. The 4 stations are Beograd. Szeged, Zagreb, and Sofia (Tables 1 - 4). For a comparison the same windspeed probability exceedance levels for Berlin, Germany, is included (Table 5).

The period of record for the 4 stations is 1971 - 1996. This twentyfive years are sufficient to reflect the conditions of upper air data at these locations. The raw data have been received from ETAC (National Weather Record Center, Asheville, NC). Since the radiosonde data use the pressure level as altitude coordinate, the data had to be converted to the geometric height at 1 km intervals from surface to 25 km. Afterwards the data were homogenized to take care of missing observations.

Although the windspeed at these 4 stations shows a maximum around 10 km (jetstream level) with approximately the same magnitude as Berlin, the wind speeds at the upper levels 12 to 25 km are somewhat higher than at Berlin.

The wind profiles which are depicted in table form were furnished on floppy disks upon request by the MLRS system analyst.

Table 1 Wind Profiles for Beograd

KM	50%	MEAN	68%	84%	90%	95%	99%	99.9%	TOT	SUM	WIN
0	5.0	6.0	6.6	8.7	9.9	11.4	14.9	18.2	210	210	209
1	5.3	6.3	7.0	9.3	10.5	12.1	15.8	19.3	270	270	270
2	6.3	7.5	8.3	10.9	12.4	14.2	18.5	22.6	283	283	283
3	7.6	9.1	10.1	13.2	15.0	17.1	22.3	27.2	287	287	288
4	9.1	10.9	12.0	15.7	17.8	20.3	26.4	32.1	288	288	288
5	10.5	12.5	13.8	18.0	20.4	23.3	30.3	36.9	286	287	284
6	11.8	14.0	15.5	20.2	22.8	26.0	33.8	41.1	288	288	287
7	13.0	15.4	17.0	22.2	25.1	28.6	37.1	45.1	288	288	287
8	14.2	16.8	18.5	24.1	27.2	31.1	40.3	49.0	288	287	288
9	17.5	20.7	22.7	29.4	33.2	37.7	48.8	59.2	289	288	289
10	17.7	20.9	23.0	29.7	33.5	38.1	49.3	59.8	289	288	290
11	16.8	19.8	21.8	28.2	31.8	36.2	46.8	56.8	289	287	295
12	15.2	18.0	19.8	25.6	28.8	32.8	42.4	51.5	288	286	296
13	15.4	18.1	19.8	25.5	28.6	32.5	41.8	50.6	286	283	295
14	13.6	15.9	17.4	22.3	25.1	28.5	36.7	44.4	285	282	294
15	11.9	14.0	15.3	19.6	22.1	25.0	32.2	39.0	283	276	295
16	10.8	12.6	13.8	17.7	19.8	22.5	28.9	35.0	280	273	292
17	10.1	11.8	13.0	16.6	18.6	21.1	27.1	32.7	279	271	292
18	9.0	10.4	11.4	14.5	16.3	18.5	23.6	28.5	273	265	292
19	8.0	9.3	10.1	12.9	14.4	16.3	20.9	25.2	271	257	292
20	7.6	8.8	9.6	12.2	13.7	15.5	19.8	23.9	254	221	291
21	7.8	9.1	10.0	12.7	14.2	16.1	20.6	24.8	239	197	295
22	8.6	10.0	10.9	13.9	15.6	17.6	22.6	27.2	223	184	296
23	9.4	11.0	12.0	15.3	17.2	19.4	24.9	30.1	347	169	285
24	10.0	11.6	12.7	16.3	18.2	20.7	26.5	32.0	349	168	291
25	10.0	11.6	12.7	16.3	18.2	20.7	26.5	32.0	349	167	291

Last 3 columns are mean wind direction (WD).
TOTAL = ALL YEAR
SUMMER = APR - SEPT
WINTER = OCT - MAR

Table 2 Wind Profiles for Zagreb

KM	50%	MEAN	68%	84%	90%	95%	99%	99.9%	TOT	SUM	WIN
0	4.8	5.7	6.4	8.4	9.6	11.0	14.5	17.7	120	348	133
1	5.3	6.4	7.1	9.3	10.6	12.2	16.0	19.5	316	329	302
2	6.5	7.7	8.6	11.3	12.8	14.7	19.2	23.4	314	315	314
3	7.9	9.4	10.5	13.7	15.6	17.8	23.2	28.3	300	301	298
4	9.4	11.1	12.3	16.1	18.3	20.9	27.2	33.1	295	296	289
5	10.6	12.6	14.0	18.2	20.6	23.6	30.7	37.4	289	295	287
6	11.7	13.9	15.4	20.1	22.7	26.0	33.7	41.1	288	289	286
7	12.8	15.2	16.8	21.9	24.8	28.3	36.7	44.7	287	288	286
8	14.0	16.6	18.3	23.9	27.0	30.8	40.0	48.6	288	288	288
9	17.7	20.9	23.0	29.7	33.5	38.1	49.2	59.7	288	287	289
10	18.1	21.3	23.5	30.3	34.2	38.9	50.2	60.9	288	286	291
11	17.4	20.5	22.5	29.1	32.8	37.3	48.2	58.5	289	286	295
12	15.8	18.7	20.5	26.5	29.9	34.0	43.9	53.3	289	285	295
13	15.9	18.6	20.4	26.1	29.4	33.4	42.9	51.9	288	283	294
14	13.7	16.1	17.6	22.6	25.4	28.8	37.0	44.7	287	282	292
15	11.9	13.9	15.2	19.5	21.9	24.8	31.8	38.5	285	276	291
16	10.5	12.3	13.5	17.2	19.3	21.9	28.1	34.0	283	273	290
17	10.0	11.6	12.8	16.3	18.3	20.7	26.6	32.1	282	270	290
18	8.9	10.4	11.4	14.5	16.3	18.4	23.6	28.5	281	265	291
19	8.0	9.3	10.2	13.0	14.5	16.4	21.0	25.4	274	255	290
20	7.7	8.9	9.7	12.4	13.9	15.7	20.1	24.2	254	192	295
21	7.9	9.2	10.1	12.8	14.4	16.3	20.8	25.1	241	166	290
22	8.6	10.0	11.0	14.0	15.7	17.8	22.8	27.5	226	150	292
23	9.4	11.0	12.0	15.4	17.2	19.5	25.0	30.2	348	134	293
24	10.0	11.6	12.7	16.2	18.2	20.6	26.5	32.0	199	135	291
25	9.9	11.6	12.7	16.2	18.2	20.6	26.4	31.9	200	133	290

Last 3 columns are mean wind direction (WD).
TOTAL = ALL YEAR
SUMMER = APR - SEPT
WINTER = OCT - MAR

Table 3 Wind Profiles for Szeged

KM	50%	MEAN	68%	84%	90%	95%	99%	99.9%	TOT	SUM	WIN
0	5.1	6.1	6.8	8.9	10.1	11.6	15.1	18.5	256	266	240
1	5.4	6.5	7.2	9.5	10.8	12.3	16.1	19.6	282	287	269
2	6.4	7.7	8.5	11.1	12.6	14.4	18.8	22.9	285	287	283
3	7.8	9.3	10.3	13.4	15.2	17.4	22.6	27.5	286	288	284
4	9.3	11.0	12.2	15.9	18.0	20.6	26.8	32.6	287	296	283
5	10.8	12.8	14.1	18.4	20.8	23.7	30.8	37.5	285	288	282
6	12.1	14.4	15.9	20.7	23.4	26.7	34.7	42.2	286	288	284
7	13.5	16.0	17.6	22.9	25.9	29.5	38.3	46.6	287	287	286
8	14.7	17.4	19.2	25.0	28.3	32.2	41.8	50.8	287	286	288
9	18.0	21.2	23.3	30.2	34.0	38.7	50.0	60.7	286	285	287
10	18.1	21.3	23.4	30.3	34.2	38.9	50.3	61.0	288	286	290
11	17.0	20.1	22.1	28.6	32.2	36.7	47.4	57.5	290	287	296
12	15.2	17.9	19.7	25.5	28.8	32.8	42.4	51.4	289	285	295
13	14.9	17.5	19.2	24.7	27.8	31.6	40.6	49.2	286	281	294
14	12.9	15.1	16.6	21.3	23.9	27.2	35.0	42.3	285	276	293
15	11.2	13.1	14.4	18.5	20.8	23.6	30.3	36.7	282	272	291
16	10.0	11.7	12.9	16.5	18.5	21.0	27.0	32.7	279	267	290
17	9.6	11.2	12.2	15.6	17.5	19.9	25.5	30.9	276	265	290
18	8.6	10.0	11.0	14.0	15.7	17.7	22.7	27.4	269	251	285
19	7.8	9.1	9.9	12.6	14.1	16.0	20.5	24.7	268	238	287
20	7.5	8.7	9.6	12.2	13.6	15.4	19.7	23.8	255	197	288
21	7.8	9.1	9.9	12.6	14.2	16.0	20.5	24.8	224	164	297
22	8.5	9.9	10.8	13.8	15.5	17.5	22.5	27.1	212	149	298
23	9.3	10.8	11.8	15.1	17.0	19.2	24.6	29.7	350	135	297
24	9.8	11.4	12.5	16.0	17.9	20.3	26.0	31.4	357	130	298
25	9.8	11.4	12.5	15.9	17.9	20.2	25.9	31.3	195	132	276

Last 3 columns are mean wind direction (WD).
TOTAL = ALL YEAR
SUMMER = APR - SEPT
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Table 4 Wind Profiles for Sofia

KM	50%	MEAN	68%	84%	90%	95%	99%	99.9%	TOT	SUM	WIN
0	3.9	4.7	5.3	7.0	8.0	9.2	12.0	14.7	195	213	209
1	4.3	5.2	5.8	7.7	8.8	10.0	13.2	16.1	256	285	255
2	5.5	6.5	7.3	9.6	10.8	12.4	16.2	19.8	271	329	268
3	7.0	8.3	9.2	12.1	13.7	15.7	20.5	25.0	298	302	288
4	8.6	10.2	11.3	14.8	16.8	19.2	25.0	30.4	296	301	286
5	10.1	12.0	13.3	17.3	19.6	22.4	29.1	35.5	289	298	287
6	11.4	13.6	15.0	19.5	22.1	25.2	32.8	39.9	288	296	286
7	12.7	15.0	16.6	21.6	24.4	27.9	36.2	44.0	286	288	285
8	13.9	16.4	18.2	23.6	26.7	30.5	39.5	48.1	286	288	286
9	17.3	20.3	22.4	28.9	32.6	37.0	47.9	58.1	285	285	286
10	18.0	21.2	23.4	30.2	34.0	38.7	50.0	60.7	285	284	287
11	17.9	21.1	23.2	30.0	33.8	38.5	49.7	60.3	285	283	287
12	17.1	20.1	22.1	28.6	32.2	36.6	47.3	57.4	283	279	288
13	17.7	20.8	22.8	29.3	32.9	37.4	48.1	58.2	280	273	287
14	16.0	18.7	20.5	26.3	29.6	33.6	43.2	52.3	277	270	286
15	14.2	16.6	18.2	23.4	26.3	29.8	38.3	46.4	275	268	284
16	12.7	14.8	16.2	20.8	23.4	26.5	34.1	41.2	271	261	283
17	11.8	13.7	15.1	19.3	21.7	24.6	31.6	38.1	271	262	283
18	10.4	12.1	13.3	17.0	19.1	21.6	27.8	33.5	267	252	282
19	9.1	10.6	11.6	14.8	16.6	18.8	24.1	29.1	266	250	283
20	8.2	9.6	10.5	13.4	15.0	17.0	21.8	26.3	252	213	277
21	8.0	9.3	10.2	13.0	14.5	16.4	21.1	25.4	241	194	283
22	8.2	9.5	10.4	13.3	14.9	16.9	21.6	26.1	235	174	277
23	8.6	10.0	11.0	14.0	15.7	17.8	22.8	27.5	207	138	291
24	8.9	10.3	11.3	14.5	16.2	18.4	23.6	28.4	200	134	287
25	8.8	10.2	11.2	14.3	16.0	18.1	23.3	28.1	200	137	285

Last 3 columns are mean wind direction (WD).
TOTAL = ALL YEAR
SUMMER = APR - SEPT
WINTER = OCT - MAR

Table 5

Wind Profiles for Berlin

KM	50%	MEAN	68%	84%	90%	95%	99%
0	5.2	6.1	6.7	8.7	9.8	11.1	14.3
1	5.4	6.4	7.0	9.1	10.2	11.7	15.0
2	6.3	7.4	8.1	10.5	11.8	13.5	17.4
3	7.5	8.9	9.7	12.6	14.2	16.1	20.8
4	9.1	10.6	11.7	15.1	17.0	19.4	25.0
5	10.9	12.8	14.1	18.2	20.6	23.4	30.2
6	13.2	15.6	17.1	22.1	24.9	28.3	36.6
7	16.0	18.8	20.7	26.7	20.1	34.3	44.2
8	19.0	22.3	24.6	31.7	35.7	40.6	52.5
9	23.6	27.8	30.6	39.5	44.5	50.6	65.4
10	24.1	28.3	31.1	40.2	45.3	51.5	66.5
11	22.7	26.7	29.3	37.9	42.7	48.5	62.7
12	20.0	23.5	25.9	33.4	37.7	42.8	55.3
13	17.4	20.5	22.5	29.1	32.7	37.2	48.1
14	14.8	17.4	19.2	24.8	27.9	31.7	41.0
15	13.0	15.3	16.8	21.7	24.4	27.8	34.9
16	11.9	14.1	15.5	20.0	22.5	25.6	33.0
17	11.5	13.5	14.8	19.1	21.6	24.5	31.7
18	9.8	11.6	12.7	16.4	18.5	21.1	27.2
19	8.8	10.4	11.4	14.7	16.6	18.9	24.4
20	8.4	10.0	11.0	14.2	16.0	18.2	23.5
21	8.9	10.4	11.5	14.8	16.7	19.0	24.5
22	9.5	11.1	12.3	15.8	17.8	20.3	26.2
23	9.9	11.6	12.8	16.5	18.5	21.2	27.3
24	9.7	11.4	12.5	16.2	18.2	20.7	26.8
25	8.7	10.2	11.2	14.5	16.3	18.6	24.0

3. PREDICTING THE WIND PROFILE FOR 13 - 25 km GIVEN THE WIND PROFILE FROM SURFACE TO 12 km.

Several methods for predicting the upper air windspeed from 13 to 25 km are available. One method which most researchers would recommend is the computation of a 26 x 26 matrix of linear correlations, with coefficients for the windspeed of upper air data from 13 to 25 km. This is an elaborate system although in our age with fast working computers and CD-ROM it would not be an impossible task for field operations. However, this researcher thought of a simpler way by using some previously developed models of wind profiles by Fourier analysis. Linear correlations for A_0, A_1, A_{22} , and A_{32} of the Fourier components with the angular adjustment of the Fourier component leads to a simple system of 4 coefficients with predictions of the upper air profile. The prediction (model) is delineated in the next 4 tables for Berlin and Thule.

The model is based om the calculation of the windspeed profile by the mentioned Fourier components such as

$$(ws - wsb)/sw = A_0 + A_1 \sin\phi_1 + A_{22} \sin\phi_2 + A_{32} \sin\phi_3 + A_{33} \sin\phi_4$$

with application for 13 - 25 KM.

The symbols are as follows: ws = windspeed, wsb = mean windspeed, A's are coefficients of the Fourier system, and ϕ is the angle, adjusting for the altitude, sw is the standard deviation, and sA the same for the A.

It should be noticed that this analysis is done by partial components which does not require a factor for ϕ as in the usual Fourier analysis.

The amplitudes of the Fourier components are determined by linear correlation as

$$(A - Ab)/sA = r\ (ws - wsb)/\ sw$$

for the 5 amplitudes.

Since the mean values Ab of the amplitudes have been calculated already, and the predictor ws at altitude for which the linear correlation coefficient is calculated, no new parameters are necessary. It proved that the correlation r for A_{33} was very small thus the system can be reduced by neglecting A_{33}.

The results of the model are exemplified in Tables 6 - 9. The Tables are self explanatory. The system was provided for a datarecord of 15 years for Berlin and Thule. It was discovered that it is better to split the data into summer (4 - 9) and winter months. The top delineates the wind error which is not larger than the measurement error of 5 m/sec.

It can be noticed that all predicted windspeeds have a variance ≤ 1. The total accounted variance ranges from 70 to 74%. This may not be sufficient for critical reviewers. However, emphasis should also been given to the actual and predicted mean profile. There is virtually no bias in the mean deviations (mean Db).

This study should be considered as a pilot for further investigations. E.g. only one given windspeed below 13 km enters into the model. Some improvement would certainly be expected if more given windspeeds below 13 km would be included.

Table 6

BERLIN, SUMMER

N = 2928

LEFT VARIANCE 7.96 2.82

H	W	PW	MD	VD	VW	RAT
13	14.20	15.48	0.25	3.30	47.21	0.07
14	12.09	12.51	0.40	5.18	38.46	0.13
15	10.36	9.68	0.48	6.23	29.21	0.21
16	8.65	7.28	0.71	9.25	22.64	0.41
17	7.27	5.51	0.83	10.75	17.18	0.63
18	6.11	4.41	0.81	10.49	13.13	0.80
19	5.19	3.90	0.72	9.32	10.47	0.89
20	4.81	3.83	0.60	7.86	8.16	0.96
21	4.57	3.99	0.59	7.67	7.80	0.98
22	4.84	4.90	0.55	7.09	7.08	1.00
23	5.13	5.10	0.57	7.37	7.37	1.00
24	5.44	5.40	0.68	8.83	8.83	1.00
25	5.93	5.90	0.78	10.11	10.11	1.00

0.70

H = Altitude
W = Mean Windspeed
PW = predicted Windspeed
MD = Mean Deviation (W - WP)
VD = Variance of Deviation
VW = Variance of Windspeed
RAT = Ratio VD/VW

Table 7

BERLIN, WINTER

N = 2911
LEFT VARIANCE 73.10 8.55

H	W	PW	MD	VD	VW	RAT
13	18.63	27.30	6.07	78.93	78.72	1.00
14	17.37	23.43	2.85	37.02	68.66	0.54
15	16.46	19.17	0.74	9.62	61.53	0.16
16	15.57	15.21	0.66	8.62	58.91	0.15
17	15.34	12.15	2.02	26.30	60.50	0.43
18	15.20	10.37	3.77	48.99	65.98	0.74
19	15.49	9.95	5.19	67.47	75.16	0.90
20	15.93	10.71	5.99	77.90	87.12	0.89
21	16.67	12.21	6.46	83.93	99.41	0.84
22	17.71	13.93	7.15	92.98	113.94	0.82
23	18.74	15.34	8.35	108.51	131.71	0.82
24	20.04	16.07	10.33	134.31	153.96	0.87
25	21.75	16.00	13.52	175.70	178.04	0.99

0.70

H = Altitude
W = Mean Windspeed
PW = predicted Windspeed
MD = Mean Deviation (W - WP)
VD = Variance of Deviation
VW = Variance of Windspeed
RAT = Ratio VD/VW

Table 8

THULE, SUMMER

N = 2928
LEFT VARIANCE 19.42 4.41

H	W	PW	MD	VD	VW	RAT
13	7.68	10.45	0.74	9.67	21.39	0.45
14	6.91	8.28	0.16	2.07	19.14	0.11
15	6.46	6.25	0.16	2.09	18.41	0.11
16	6.01	4.61	0.62	8.08	19.62	0.41
17	5.68	3.52	1.09	14.20	20.39	0.70
18	5.47	3.00	1.58	20.50	23.74	0.86
19	5.38	2.96	2.10	27.29	29.99	0.91
20	5.37	3.22	1.72	22.40	25.25	0.89
21	5.43	3.56	1.97	25.60	30.05	0.85
22	5.68	3.78	2.10	27.25	31.46	0.87
23	5.90	3.79	2.34	30.47	33.38	0.91
24	6.03	3.56	2.41	31.37	31.78	0.99
25	6.18	3.19	2.43	31.53	28.88	1.09

0.70

H = Altitude
W = Mean Windspeed
PW = predicted Windspeed
MD = Mean Deviation (W - WP)
VD = Variance of Deviation
VW = Variance of Windspeed
RAT = Ratio VD/VW

Table 9

THULE, WINTER

N = 2911
LEFT VARIANCE 94.32 9.71

H	W	PW	MD	VD	VW	RAT
13	10.58	14.19	1.13	14.67	26.01	0.56
14	10.84	13.17	0.76	9.83	27.94	0.35
15	11.11	12.04	0.93	12.04	32.38	0.37
16	11.97	11.36	1.58	20.50	39.53	0.52
17	12.95	11.57	2.89	37.60	55.35	0.68
18	14.30	12.87	4.96	64.53	82.11	0.79
19	15.70	15.19	6.70	87.16	108.61	0.80
20	17.09	18.19	10.19	132.50	140.93	0.94
21	18.42	21.28	8.83	114.85	130.65	0.88
22	20.08	23.81	11.07	143.97	156.25	0.92
23	20.82	25.19	12.69	164.97	170.96	0.96
24	20.96	25.01	15.90	206.66	217.16	0.95
25	22.20	23.16	16.68	216.90	244.66	0.89

-- 0.74

H = Altitude
W = Mean Windspeed
PW = predicted Windspeed
MD = Mean Deviation (W - WP)
VD = Variance of Deviation
VW = Variance of Windspeed
RAT = Ratio VD/VW

4. PREDICTING VEERING OR BACKING OF THE WIND IN THE BOUNDARY LAYER.

The last research task was the preparation of a multiple regression model to predict veering or backing of the wind in the boundary layer. The "EKMAN spiral" is a theoretical model, and the veering is caused by surface friction. However, in the practical application for some stations veering and backing of the wind are almost of equal occurrence.

Unfortunately veering and backing of the wind from surface to 300 and 600 meters above ground showed only a weak linear correlation with other parameters. Thus it was finally attempted to predict the wind direction at 300 and 600 meters above ground directly, and evaluate veering and backing.

The result can be found in Tables 10 - 18.

Tables 10 and 11 for Berlin and Thule, respectively, provide the result of the prediction for these stations.

The correct predictions range from 60 to 80 %, where Berlin discloses a better result than Thule. This may be due to the fact that cold and warm air advection is not properly accounted for with the present model. This may have a larger impact in Thule than in Berlin.

The next 4 tables (12 - 15) provide more details of the analysis for Berlin. Table 12 delineates the linear correlations matrix for the model for the total year and separated by winter and summer (4 - 9) months.

The next 3 tables show the correct and incorrect prediction by the wind direction as entry. It can be noticed that there is a component maximum for easterly and westerly winds.

The same tabulations have been established for Thule. In essence they resemble the result for Berlin except that the prediction is better for Berlin.

The coefficients for the multiple regression system were obtained by the method of matrix inversion, one of the mathematical tools to obtain coefficients for a multiple regression system.

Table 10

Berlin, Germany

Total Year
N = 3505

	300m PV	300m PB	600m PV	600m PB
OV	56.9%	14.5%	64.8%	9.3%
OB	8.6	20.0	12.8	13.1
Correct:	76.9%		77.9%	
Not correct:	23.1		22.1	

Winter
N = 2220

	300m PV	300m PB	600m PV	600m PB
OV	66.9	13.4	63.1	19.5
OB	6.5	13.2	8.6	8.8
Correct:	80.1		71.9	
Not correct:	19.9		28.1	

Summer
N = 1285

	300m PV	300m PB	600m PV	600m PB
OV	35.1	20.9	15.6	43.8
OB	9.7	34.3	5.1	35.5
Correct:	69.4		51.9	
Not correct:	30.6		48.9	

Table 11

Thule, Greenland

		300m		600m	
Total Year N = 3816		PV	PB	PV	PB
	OV	22.9%	27.5%	17.7%	31.8%
	OB	12.0	37.6	9.4	41.1
Correct:		60.5%		58.8%	
Not correct:		39.5		41.2	
Winter N = 2083		PV	PB	PV	PB
	OV	18.9	28.0	9.6	35.5
	OB	1.8	51.3	3.9	51.0
Correct:		70.2		60.6	
Not correct:		29.8		39.4	
Summer N = 1733		PV	PB	PV	PB
	OV	25.7	29.1	29.5	25.2
	OB	23.4	21.8	18.7	26.6
Correct:		47.5		56.1	
Not correct:		52.5		43.9	

Table 12

ALL YEAR BERLIN, GERMANY

Correlation Matrix for x's and y1

	x1	x12	x17	x18	x19	x21	x22	y1
x1	1	0.14	0.14	0.77	0.73	0.15	-0.04	0.77
x12	0.14	1	0.05	0.13	0.13	0.01	0.01	0.12
x17	0.14	0.05	1	0.20	0.20	0.03	-0.25	0.13
x18	0.77	0.13	0.20	1	0.97	0.13	-0.06	0.83
x19	0.73	0.13	0.20	0.97	1	0.12	-0.05	0.87
x21	0.15	0.01	0.03	0.13	0.12	1	-0.12	0.10
x22	-0.04	0.01	-0.25	-0.06	-0.05	-0.12	1	-0.04

WINTER BERLIN, GERMANY

Correlation Matrix for x's and y1

	x1	x12	x17	x18	x19	x21	x22	y1
x1	1	0.20	0.22	0.93	0.90	0.27	-0.06	0.83
x12	0.20	1	0.06	0.20	0.20	0.01	-0.01	0.16
x17	0.22	0.06	1	0.22	0.21	0.2	-0.26	0.16
x18	0.93	0.20	0.22	1	0.98	0.27	-0.05	0.87
x19	0.90	0.20	0.21	0.98	1	0.27	-0.06	0.90
x21	0.27	0.01	0.20	0.27	0.27	1	-0.14	0.24
x22	-0.06	-0.01	-0.26	-0.05	-0.06	-0.14	1	-0.06

SUMMER BERLIN, GERMANY

Correlation Matrix for x's and y1

	x1	x12	x17	x18	x19	x21	x22	y1
x1	1	0.07	-0.03	0.30	0.29	-0.22	0.08	0.73
x12	0.07	1	0.04	0.03	0.04	-0.02	0.06	0.08
x17	-0.03	0.04	1	0.20	0.21	-0.11	-0.23	0.02
x18	0.30	0.03	0.20	1	1.[illegible]	-0.10	-0.05	0.77
x19	0.29	0.04	0.21	1.[illegible]	1	-0.11	-0.04	0.82
x21	-0.22	-0.02	-0.11	-0.10	-0.11	1	0.09	-0.21
x22	0.08	0.06	-0.23	-0.05	-0.04	0.09	1	0.09

y1: Wind Direction (WD) at 300m (deg)

x1: WD at Surface (Sfc) (deg)
x12: Change in WD at Sfc over Previous 24hr.
x17: Wind Speed (WS) at Sfc (tenths of m/s)
x18: WD at 100m (deg)
x19: WD at 150m (deg)
x21: Sfc Temperature (tenths of deg K)
x22: Surface Pressure (milibars)

Table 13 BERLIN, GERMANY

Total samples: 3505 ALL YEAR

PREDICTIONS FOR 300M				PREDICTIONS FOR 600M			
VV:	1994	509	BV	VV:	2271	327	BV
VB:	302	700	BB	VB:	449	458	BB

where VV = Predicted Veering/Observed Veering,
BB = Predicted Backing/Observed Backing,
BV = Predicted Backing/Observed Veering,
VB = Predicted Veering/Observed Backing.

A Count by Surface Wind Direction of the cases in each Category:

ALL YEAR		Y1=300m				Y2=600m			
Sfc WD	TOTAL	VV	BB	BV	VB	VV	BB	BV	VB
0- 9	13	0	7	6	0	0	7	6	0
10- 19	44	12	14	18	0	5	13	26	0
20- 29	43	29	7	7	0	26	6	10	1
30- 39	49	30	9	2	8	28	8	3	10
40- 49	41	31	2	0	8	30	2	0	9
50- 59	64	47	2	0	15	45	0	1	18
60- 69	45	30	0	0	15	30	0	0	15
70- 79	77	65	3	0	9	69	0	0	8
80- 89	89	76	3	0	10	75	0	0	14
90- 99	126	106	0	0	20	103	0	0	23
100-109	102	88	2	0	12	86	2	0	14
110-119	99	70	2	0	27	73	0	0	26
120-129	115	85	5	0	25	84	1	0	30
130-139	111	89	1	0	21	83	0	0	28
140-149	115	86	5	1	23	88	2	0	25
150-159	114	90	6	0	18	90	1	0	23
160-169	100	80	6	1	13	80	1	1	18
170-179	89	74	5	2	8	75	2	1	11
180-189	121	99	7	1	14	104	3	1	13
190-199	136	110	13	2	11	112	5	3	16
200-209	123	109	5	1	8	112	2	1	8
210-219	133	110	15	2	6	112	5	4	12
220-229	140	119	14	0	7	120	6	4	10
230-239	86	59	15	4	8	66	6	2	12
240-249	132	79	34	10	9	97	13	4	18
250-259	136	59	44	29	4	87	16	10	23
260-269	175	51	66	58	0	107	36	16	16
270-279	196	37	76	83	0	102	44	28	22
280-289	151	14	69	66	2	57	44	34	16
290-299	127	12	71	44	0	36	59	28	4
300-309	100	9	54	37	0	25	45	29	1
310-319	105	13	43	49	0	25	41	37	2
320-329	77	12	32	33	0	20	30	25	2
330-339	55	7	27	20	1	11	26	17	1
340-349	28	0	16	12	0	1	13	14	0
350-359	21	4	11	6	0	5	10	6	0

Table 14 BERLIN, GERMANY

Total samples: 2220 WINTER

PREDICTIONS FOR 300M

VV:	1485	299	BV
VB:	145	291	BB

PREDICTIONS FOR 600M

VV:	1401	434	BV
VV:	191	194	BB

where VV = Predicted Veering/Observed Veering,
BB = Predicted Backing/Observed Backing,
BV = Predicted Backing/Observed Veering,
VB = Predicted Veering/Observed Backing.

A Count by Surface Wind Direction of the cases in each Category:

WINTER		Y1=300m				Y2=600m			
Sfc WD	TOTAL	VV	BB	BV	VB	VV	BB	BV	VB
0- 9	5	1	2	2	0	1	2	2	0
10- 19	21	5	6	10	0	5	6	10	0
20- 29	27	17	6	4	0	16	6	4	1
30- 39	22	10	4	2	6	10	3	3	6
40- 49	18	14	1	0	3	14	1	0	3
50- 59	36	27	2	0	7	25	2	0	9
60- 69	27	21	1	0	5	22	0	0	5
70- 79	44	41	0	0	3	41	0	0	3
80- 89	55	53	0	0	2	52	0	0	3
90- 99	87	78	0	0	9	76	0	0	11
100-109	74	69	1	0	4	67	0	0	7
110-119	76	56	1	0	19	54	0	0	22
120-129	78	60	1	0	17	58	0	0	20
130-139	87	70	2	0	15	67	0	0	20
140-149	82	66	5	2	9	68	0	0	14
150-159	82	72	3	0	7	71	0	0	11
160-169	68	60	2	1	5	60	0	0	8
170-179	67	60	4	1	2	60	1	0	6
180-189	94	81	4	0	9	84	0	0	10
190-199	106	92	7	1	6	94	2	2	8
200-209	97	88	3	2	4	92	1	1	3
210-219	92	80	8	2	2	82	3	2	5
220-229	105	92	7	4	2	96	1	3	5
230-239	63	50	8	3	2	53	6	2	2
240-249	87	62	14	9	2	66	10	9	2
250-259	83	40	18	23	2	31	11	37	4
260-269	103	36	25	42	0	17	17	69	0
270-279	117	34	35	47	1	10	25	81	1
280-289	73	13	27	32	1	1	17	54	1
290-299	60	9	29	22	0	3	23	33	1
300-309	46	4	16	26	0	1	12	33	0
310-319	48	7	16	25	0	1	15	32	0
320-329	35	6	14	14	1	0	13	22	0
330-339	25	4	9	12	0	0	8	17	0
340-349	10	1	4	5	0	0	3	7	0
350-359	7	4	2	1	0	1	1	5	0

Table 15 BERLIN, GERMANY

Total samples: 1288 SUMMER

PREDICTIONS FOR 300M				PREDICTIONS FOR 600M			
VV:	450	269	BV	VV:	199	564	BV
VB:	125	441	BB	VV:	66	456	BB

where VV = Predicted Veering/Observed Veering,
BB = Predicted Backing/Observed Backing,
BV = Predicted Backing/Observed Veering,
VB = Predicted Veering/Observed Backing.

A Count by Surface Wind Direction of the cases in each Category:

SUMMER		Y1=300m				Y2=600m			
Sfc WD	TOTAL	VV	BB	BV	VB	VV	BB	BV	VB
0- 9	8	0	5	3	0	0	5	3	0
10- 19	23	7	8	8	0	5	6	11	1
20- 29	16	12	1	3	0	12	0	4	0
30- 39	27	20	5	0	2	17	5	1	4
40- 49	23	17	1	0	5	10	1	6	6
50- 59	28	20	1	0	7	16	2	5	5
60- 69	18	9	0	0	9	4	5	4	5
70- 79	33	24	3	0	6	18	2	10	3
80- 89	34	23	2	0	9	10	5	13	6
90- 99	39	28	0	0	11	12	6	15	6
100-109	28	19	2	0	7	8	5	11	4
110-119	23	14	0	0	9	7	2	12	2
120-129	37	25	4	0	8	10	8	16	3
130-139	24	19	1	0	4	9	8	7	0
140-149	33	19	2	0	12	6	10	14	3
150-159	32	18	3	0	11	3	12	16	1
160-169	32	20	5	0	7	5	10	16	1
170-179	22	14	3	1	4	2	6	14	0
180-189	27	18	5	1	3	5	6	16	0
190-199	30	17	11	2	0	0	11	19	0
200-209	26	14	4	6	2	3	5	17	1
210-219	41	20	11	10	0	4	8	28	1
220-229	35	14	10	9	2	5	10	20	0
230-239	23	5	12	5	1	1	10	12	0
240-249	45	9	26	9	1	3	18	23	1
250-259	53	11	25	14	3	4	24	25	0
260-269	72	5	40	26	1	0	34	37	1
270-279	79	6	40	33	0	2	37	37	3
280-289	78	4	43	31	0	4	42	32	0
290-299	67	3	42	22	0	2	35	26	4
300-309	54	2	38	14	0	1	30	19	4
310-319	57	5	27	25	0	4	27	25	1
320-329	42	5	17	20	0	1	19	22	0
330-339	30	2	18	9	1	3	19	8	0
340-349	18	0	12	6	0	0	10	8	0
350-359	14	1	9	4	0	1	9	4	0

Table 16

ALL YEAR THULE, GREENLAND

Correlation Matrix for x's and y1

	x1	x12	x17	x18	x19	x21	x22	y1
x1	1	0.22	-0.13	0.75	0.70	0.44	0.04	-0.09
x12	0.22	1	-0.02	0.23	0.21	0.04	0.00	-0.03
x17	-0.13	-0.02	1	-0.17	-0.16	0.03	-0.03	0.20
x18	0.75	0.23	-0.17	1	1.0	0.50	0.05	-0.05
x19	0.70	0.21	-0.16	1.0	1	0.48	0.05	0.20
x21	0.44	0.04	0.03	0.50	0.48	1	0.08	-0.02
x22	0.04	0.00	-0.03	0.05	0.05	0.08	1	0.02

WINTER THULE, GREENLAND

Correlation Matrix for x's and y1

	x1	x12	x17	x18	x19	x21	x22	y1
x1	1	0.41	0.13	0.30	0.28	0.08	-0.04	0.16
x12	0.41	1	0.08	0.32	0.27	0.06	0.00	0.11
x17	0.13	0.08	1	0.00	0.01	0.23	0.03	0.14
x18	0.30	0.32	0.00	1	1.0	0.15	-0.06	0.35
x19	0.28	0.27	0.01	1.0	1	0.14	-0.01	0.53
x21	0.08	0.06	0.23	0.15	0.14	1	0.01	0.13
x22	-0.04	0.00	0.03	-0.06	-0.01	0.01	1	0.07

SUMMER THULE, GREENLAND

Correlation Matrix for x's and y1

	x1	x12	x17	x18	x19	x21	x22	y1
x1	1	0.25	-0.24	0.89	0.80	0.37	-0.04	-0.35
x12	0.25	1	-0.08	0.23	0.20	0.02	0.00	-0.11
x17	-0.24	-0.08	1	-0.22	-0.20	0.07	-0.09	0.25
x18	0.89	0.23	-0.22	1	0.90	0.34	-0.04	-0.39
x19	0.80	0.20	-0.20	0.90	1	0.32	-0.06	-0.41
x21	0.37	0.02	0.07	0.34	0.32	1	-0.22	-0.09
x22	-0.04	0.00	-0.09	-0.04	-0.06	-0.22	1	-0.01

y1: Wind Direction (WD) at 300m (deg)

x1: WD at Surface (Sfc) (deg)
x12: Change in WD at Sfc over Previous 24hr.
x17: Wind Speed (WS) at Sfc (tenths of m/s)
x18: WD at 100m (deg)
x19: WD at 150m (deg)
x21: Sfc Temperature (tenths of deg K)
x22: Surface Pressure (milibars)

Table 17 THULE, GREENLAND

Total samples: 3816 ALL YEAR

PREDICTIONS FOR 300M				PREDICTIONS FOR 600M			
VV:	874	1052	BV	VV:	673	1213	BV
VB:	458	1432	BB	VB:	362	1568	BB

where VV = Predicted Veering/Observed Veering,
BB = Predicted Backing/Observed Backing,
BV = Predicted Backing/Observed Veering,
VB = Predicted Veering/Observed Backing.

A Count by Surface Wind Direction of the cases in each Category:

ALL YEAR		Y1=300m				Y2=600m			
Sfc WD	TOTAL	VV	BB	BV	VB	VV	BB	BV	VB
0- 9	1	0	0	0	1	1	0	0	0
10- 19	8	4	0	0	4	6	0	0	2
20- 29	10	6	0	0	4	5	0	0	5
30- 39	15	9	0	0	6	10	0	0	5
40- 49	22	16	0	0	6	14	0	0	8
50- 59	22	20	0	0	2	19	0	0	3
60- 69	36	25	0	0	11	20	1	3	12
70- 79	75	52	4	1	18	44	7	9	15
80- 89	167	90	34	7	36	56	50	25	36
90- 99	563	168	241	86	68	95	279	146	43
100-109	378	55	178	135	10	35	180	154	9
110-119	495	32	261	198	4	23	263	202	7
120-129	363	24	189	147	3	25	177	158	3
130-139	197	16	92	84	5	15	79	98	5
140-149	106	2	60	43	1	3	56	46	1
150-159	102	5	52	45	0	2	49	51	0
160-169	103	0	67	36	0	0	66	37	0
170-179	83	0	54	29	0	0	59	24	0
180-189	76	0	52	24	0	0	55	21	0
190-199	22	0	15	7	0	0	17	5	0
200-209	37	0	22	15	0	0	23	14	0
210-219	21	0	8	13	0	0	12	9	0
220-229	15	0	5	10	0	0	8	7	0
230-239	21	0	9	12	0	0	13	8	0
240-249	45	3	23	19	0	1	25	18	1
250-259	55	11	19	24	1	8	18	27	2
260-269	83	20	16	33	14	15	33	26	9
270-279	159	37	19	67	36	29	53	58	19
280-289	133	74	7	15	37	42	31	39	21
290-299	134	75	3	2	54	50	14	23	47
300-309	88	51	0	0	37	49	0	5	34
310-319	41	15	0	0	26	19	0	0	22
320-329	45	20	0	0	25	27	0	0	18
330-339	44	16	1	0	27	25	0	0	19
340-349	20	10	1	0	9	11	0	0	9
350-359	12	7	0	0	5	11	0	0	1

Table 18 THULE, GREENLAND

Total samples: 2083 WINTER

PREDICTIONS FOR 300M				PREDICTIONS FOR 600M			
VV:	391	585	BV	VV:	198	740	BV
VB:	39	1068	BB	VB:	82	1063	BB

where VV = Predicted Veering/Observed Veering,
BB = Predicted Backing/Observed Backing,
BV = Predicted Backing/Observed Veering,
VB = Predicted Veering/Observed Backing.

A Count by Surface Wind Direction of the cases in each Category:

WINTER		Y1=300m				Y2=600m			
Sfc WD	TOTAL	VV	BB	BV	VB	VV	BB	BV	VB
0- 9	0	0	0	0	0	0	0	0	0
10- 19	3	1	1	0	1	2	0	0	1
20- 29	5	3	1	0	1	2	1	0	2
30- 39	4	3	0	0	1	3	0	0	1
40- 49	11	8	1	1	1	5	2	1	3
50- 59	13	8	2	3	0	9	2	2	0
60- 69	25	15	6	4	0	10	6	6	3
70- 79	54	30	11	12	1	25	11	14	4
80- 89	128	40	55	32	1	22	64	34	8
90- 99	467	107	252	96	12	49	255	144	19
100-109	284	51	151	80	2	13	147	118	6
110-119	373	58	201	112	2	16	213	139	5
120-129	238	30	134	73	1	14	127	95	2
130-139	107	8	51	47	1	4	45	57	1
140-149	59	5	35	19	0	1	33	25	0
150-159	54	1	33	20	0	0	30	24	0
160-169	50	4	32	14	0	0	29	21	0
170-179	43	3	26	14	0	0	27	16	0
180-189	32	1	20	11	0	0	19	13	0
190-199	9	0	6	3	0	0	8	1	0
200-209	11	0	3	8	0	0	4	7	0
210-219	7	0	3	4	0	0	5	2	0
220-229	6	0	3	3	0	0	3	3	0
230-239	5	0	3	2	0	0	4	1	0
240-249	13	1	7	5	0	1	9	3	0
250-259	5	0	3	2	0	1	3	1	0
260-269	6	0	5	1	0	0	6	0	0
270-279	11	0	4	6	1	0	5	3	3
280-289	8	0	1	7	0	2	1	5	0
290-299	7	0	3	3	1	1	2	1	3
300-309	8	1	4	3	0	3	0	1	4
310-319	4	0	3	0	1	0	0	0	4
320-329	12	4	6	0	2	5	2	1	4
330-339	6	1	1	0	4	1	0	1	4
340-349	3	1	0	0	2	1	0	1	1
350-359	6	4	0	0	2	5	0	0	1

Table 19 THULE, GREENLAND

Total samples: 1733 SUMMER

PREDICTIONS FOR 300M				PREDICTIONS FOR 600M			
VV:	444	506	BV	VV:	510	438	BV
VB:	406	377	BB	VB:	325	460	BB

where VV = Predicted Veering/Observed Veering,
BB = Predicted Backing/Observed Backing,
BV = Predicted Backing/Observed Veering,
VB = Predicted Veering/Observed Backing.

A Count by Surface Wind Direction of the cases in each Category:

SUMMER		Y1=300m				Y2=600m			
Sfc WD	TOTAL	VV	BB	BV	VB	VV	BB	BV	VB
0- 9	1	0	0	0	1	1	0	0	0
10- 19	5	3	0	0	2	4	0	0	1
20- 29	5	3	0	0	2	3	0	0	2
30- 39	11	6	0	0	5	7	0	0	4
40- 49	11	7	0	0	4	8	0	0	3
50- 59	9	9	0	0	0	8	0	0	1
60- 69	11	6	0	0	5	7	0	0	4
70- 79	21	11	0	0	10	14	0	0	7
80- 89	39	23	0	2	14	23	0	2	14
90- 99	96	27	5	24	40	21	22	27	26
100-109	94	16	25	43	10	13	33	45	3
110-119	122	9	53	51	9	8	47	62	5
120-129	125	10	55	58	2	7	50	67	1
130-139	90	5	43	40	2	3	37	49	1
140-149	47	1	26	20	0	0	24	23	0
150-159	48	0	19	29	0	0	19	29	0
160-169	53	0	35	18	0	0	37	16	0
170-179	40	0	28	12	0	0	32	8	0
180-189	44	0	32	12	0	0	36	8	0
190-199	13	0	9	4	0	0	9	4	0
200-209	26	0	19	7	0	0	19	7	0
210-219	14	2	5	7	0	0	7	7	0
220-229	9	3	2	4	0	0	5	4	0
230-239	16	8	1	2	5	0	9	7	0
240-249	32	14	2	2	14	1	17	14	0
250-259	50	24	1	9	16	8	16	25	1
260-269	77	33	3	19	22	28	21	13	15
270-279	148	69	2	29	48	78	15	6	49
280-289	125	46	2	36	41	65	2	9	49
290-299	127	42	0	32	53	67	2	4	54
300-309	80	24	1	23	32	49	0	1	30
310-319	37	7	2	8	20	18	1	1	17
320-329	33	3	0	13	17	21	0	0	12
330-339	38	15	5	0	18	23	0	0	15
340-349	17	7	1	2	7	9	0	0	8
350-359	6	3	1	0	2	6	0	0	0

5. SUMMARY.

This report is divided into 3 research sections in agreement with the scope of work.

In the first section (2) windspeed profiles for 4 stations in the area of former Yugoslavia and Balkan were calculated for probability thresholds of exceedance. The result was compared with some earlier profiles for Berlin, Germany. We learn that the wind speed speed profiles of exceedance are about similar as for Berlin except above 12 km. Deviations exist for the mean directional values. The profiles were also furnished on floppy disks upom request by the MLRS system.

The second section (3) studied the prediction of the windspeed profile from 13 to 25 km, given the windspeed from surface to 12 km. A simple model was derived as a pilot study using Fourier components as utilized for the probability profiles. Instead of a 26 by 26 matrix system for predictions it was shown that essentially a 4 coefficient model achieved 70 - 74% of the accounted variance for Berlin and Thule. However, the remaining error does not exceed the measurement error of upper air data (5 m/sec).

The last task was the establishment of a multiple regression model to predict veering or backing of the wind in the boundary layer. Since the linear correlation coefficients for predicting veering or backing directly were very weak, the attempt was made to predict the wind direction at 300 and 600 m altitude, and evaluate veering or backing. This resulted in correct predictions ranging between 60 - 80 % correct answers for Berlin and Thule. Berlin had more correct answers. Due to time limitations for the contract the study could not be expanded to seek other suitable parameters.

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